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Responses of Soil Enzyme Activities and Microbial Community Composition to Moisture Regimes in Paddy Soils Under Long-Term Fertilization Practices

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ABSTRACT

The effects of fertilization on activity and composition of soil microbial community depend on nutrient and water availability; however, the combination of these factors on the response of microorganisms was seldom studied. This study investigated the responses of soil microbial community and enzyme activities to changes in moisture along a gradient of soil fertility formed within a long-term (24 years) field experiment. Soils (0–20 cm) were sampled from the plots under four fertilizer treatments: i) unfertilized control (CK), ii) organic manure (M), iii) nitrogen, phosphorus, and potassium fertilizers (NPK), and iv) NPK plus M (NPK + M). The soils were incubated at three moisture levels: constant submergence, five submerging-draining cycles (S-D cycles), and constant moisture content at 40% water-holding capacity (low moisture). Compared with CK, fertilization increased soil organic carbon (SOC) by 30.1%–36.3%, total N by 27.3%–38.4%, available N by 35.9%–56.4%, available P by 61.4%–440.9%, and total P by 28.6%–102.9%. Soil fertility buffered the negative effects of moisture on enzyme activities and microbial community composition. Enzyme activities decreased in response to submergence and S-D cycles *versus* low moisture. Compared with low moisture, S-D cycles increased total phospholipid fatty acids (PLFAs) and actinomycete, fungal, and bacterial PLFAs. The increased level of PLFAs in the unfertilized soil after five S-D cycles was greater than that in the fertilized soil. Variations in soil microbial properties responding to moisture separated CK from the long-term fertilization treatments. The coefficients of variation of microbial properties were negatively correlated with SOC, total P, and available N. Soils with higher fertility maintained the original microbial properties more stable in response to changes in moisture compared to low-fertility soil.

Key Words: microbial property, phospholipid fatty acids, soil fertility, submergence, submerging-draining cycle

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Fertilization is an important management option to increase soil fertility and crop yield, but the effects of fertilization regimes are soil specific. Microbial community composition and enzyme activity are sensitive indicators of ongoing changes in soil, which cannot be easily achieved with other parameters at early stages (Börjesson *et al.*, 2012). Long-term fertilization has been shown to strongly influence soil microbial composition and increase the expression of enzyme-encoding genes (Su *et al.*, 2015). Compared with the application of mineral fertilizers, combined mineral and organic fertilization accelerates microbial growth and soil enzyme activities (Liu *et al.*, 2010; Lazcano *et al.*, 2013; Ai *et al.*, 2015). Microbial coummunity and enzyme activities are sensitive to changes in soil moisture (Gordon *et al.*, 2008; Unger *et al.*, 2009; Kechavarzi *et al.*, 2010), but it is not clear how the microbial community and enzyme activities respond to changes in soil moisture depending on fertilization regimes. The effects of moisture on microbial properties can be modi-

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